SYLLABUS

for

MASTER OF SCIENCE (M.Sc.)

PHYSICS

(To be implemented from June-2023)

VEER NARMAD SOUTH GUJARAT UNIVERSITY,
UDHNA MAGDALLA ROAD,
SURAT-395007. (GUJARAT)

PROGRAMME STRUCTURE
Master of Science in Physics – M. Sc. - PHYSICS
Syllabus with effect from the Academic Year 2023-2024

Name of Programme	Master of Science in Physics
Abbreviation	M.Sc. - Physics
Duration	2 Years
Eligibility Criteria	B. Sc. Physics
Medium of Instruction	English
Objective of Program	The objective of the M.Sc. (Physics) program is to mold the students for building their carrier in research as well as in other allied fields.
Programme Specific Outcome (PSO)	(1) Enhancement of the student's knowledge in the subject. (2) Impartment of quality education to the students in the subject through well designed course of fundamental concept and technological importance. (3) Student's skill and capabilities building in the field of research and developments. (4) Students are trained for scientific approach and be able to work with quality, objectivity, ethical responsibilities, efficiency, accuracy and precision.

Structure for MSc Physics – Semester - I							
Course Type	Course Code	Course Name	Teaching hours/week	Credit	Internal Marks	External Marks	Total Marks
Core	PH-411	Mathematical Methods of Physics	04	04	30	70	100
	PH-412	Classical Mechanics	04	04	30	70	100
	PH-413	General Electronics	04	04	30	70	100
Elective (Any one course can be taken)	PH-414	Elective 1: Physics of Semiconductor Devices	04	04	30	70	100
		Elective 2: Crystal Growth and Characterization	04	04	30	70	100
		Elective 3: Numerical Methods	04	04	30	70	100
		Elective 4: Basic Nuclear Properties and Radioactivity	04	04	30	70	100
	PH-415	Practical	12	06	50	100	150
Skill based course	PH-416	Measurement and Industrial Instrumentation	02	02	20	30	50
		Total	30	24	190	410	600

Course Name	**PH-411: Mathematical Methods of Physics**
Course Code	PH-411
Course Type	Core
Course Outcome (CO)	(1) By studying this course students will be able to learn different mathematical methods to solve different physical problems. (2) Students are able to solve differential equations using different methods. (3) Students are able to develop a skill to evaluate contour integral and integral transform. (4) Students are able to learn special functions in detail. (5) Students will get conceptual knowledge and application of probability and group theory.

Course Content	
Unit 1	**Ordinary Differential Equations:** **Solution in Closed form:** First and second order differential equations: Separable equation, exact equation, linear equation, Bernoulli's equation, Clairaut equation, Homogeneous and inhomogeneous forms, undetermined coefficients method, Variation of parameter method, change of variable method, Power Series Solutions: General theory of series solutions of linear differential equation, Legendre's differential equation, Bessel's differential equation, Schrodinger equation for a one dimensional quantum mechanical harmonic oscillator, Associated Legendre's differential equation, Miscellaneous approximate methods: Graphical approach, dropping small terms and iterating approach, WKB method.
Unit 2	**Evaluation of Integrals and Integral Transforms:** Evaluation of Integrals: Residue Theorem, Methods to find out Residues, Contour integration, Integral Transforms: Fourier transforms, integral representation of delta function, Parseval's theorem, Fourier cosine transforms, Fourier sine transforms, Laplace transforms, other transforms pairs, Applications of integral transforms-Linearity, Derivatives, Integrals, Translation, Multiplication by an exponential, Multiplication by a power of x, Convolution theorems .
Unit 3	**Special Functions:** Legendre functions: Rodrigues' formula, Schlafli's integral representation, Laplace's integral representation, Generating function, recursion relations, orthogonality and normalization properties of the Legendre polynomial, Associated Legendre functions, orthogonality and normalization properties of the Associated Legendre polynomial, Spherical Harmonics, Bessel Functions: Generating function, recursion relations, orthogonality and normalization properties of the Bessel functions, integral and half integral orders, Schlafli's integral representation, Bessel's integral representation, Hankel functions
Unit 4	**Probability and Group Theory:** Probability: Priori and posteriori probabilities, Fundamental probabilities laws, Bayes' theorem, Combinations and permutations, Binomial, Poisson, and Gaussian distributions, General properties of distributions, Multivariate Gaussian distributions, Fitting of experimental data, chi-square test, Group Theory: Introduction and definitions – Group, finite group, order of group, Abelian group, symmetric group, Subgroup and classes, Group representations.

Reference Books	
1.	Mathematical Methods of Physics: Mathews and Walker, 2nd Edition, Pearson Education, 2004.
2.	Mathematical Methods for Physicists: G. Arfken and H. J. Weber, 7th Edition, Academic Press, 2013.
3.	Mathematical Physics: P. K. Chattopadhyay, Wiley Eastern Limited, 1990
4.	Mathematical Methods: B. S. Rajput, Pragati Prakashan, 1997.
5.	Mathematical Physics: B. D. Gupta, Vikas Publishing House Pvt Ltd, 3rd Edition, 2004.
6.	Elements of Group Theory for Physicists: A.W.Joshi, New Age International Publication, 1997.

Course Name	**PH-412: Classical Mechanics**
Course Code	PH-412
Course Type	Core
Course Outcome (CO)	(1) To develop basic understanding of Lagrangian formulation & Hamilton formulation. (2) To understand the kepler force problem and to apply Lagrangian formulation for solving the kepler's problem. (3) To apply Lagrangian formulation to study liquid body dynamics. (4) To study small oscillation and understand vibration of liner tri-atomic molecules. (5) To understand canonical transformations, Poisson Brackets.

Course Content	
Unit 1	**Central Force Problem:** Reduction of two body problem to one body problem; equation of motion and first integrals; equivalent one-dimensional problem; classification of orbits; differential equation for the orbit; power law potentials; Bertrand's theorem; Kelper's laws; Scattering in a central force field; Rutherford scattering cross section.
Unit 2	**Rigid Body Motion:** Independent coordinates of a rigid body; Orthogonal transformations; transformation matrix; Euler-angles; Euler theorem; angular momentum; kinetic energy; moment of Inertia tensor; principal axis transformation; Euler's and Lagrangian treatment of rigid body motion; force free motion of a symmetrical top; motion of a heavy symmetrical top with one point fixed.
Unit 3	**Small Oscillations:** Eigen-value equation and principal axis transformation; normal modes and normal coordinates for small oscillations; examples: Free vibrations of a linear tri-atomic molecule, coupled pendulums, double pendulum. Hamilton's Equations of Motion: Legendre transformation and Hamiltonian function; canonical equations of motion; examples; ignorable coordinates and conservation theorems; Cyclic coordinates and Routh's procedure; modified Hamilton's Principle.
Unit 4	**Canonical Transformations:** I Generators of Canonical transformations, Equations of canonical transformations; examples; the Harmonic oscillator; The integral invariance of Poincaré and Lagrange and Poisson Brackets; Equation of Motion in Poisson bracket; Infinitesimal canonical transformation; constant of motion and symmetry properties; angular momentum Poisson brackets. Hamilton-Jacobi Theory: Hamilton-Jacobi equation; Hamilton's principal and characteristic function; examples; separation of variables in Hamilton-Jacobi equation; orbit equation for central force problem; periodicity and action angle variables, frequencies of periodic motion.

Reference Books	
1.	Classical Mechanics: H. Goldstein, (3rd Ed)., Pearson education, 2002 / (2nd Ed)., Addison Wesley, 1980
2.	Classical Dynamics of Particles and Systems: J.B. Marion and S.T. Thronton, (4th Ed)., Saunders College Publishing, 1995
3.	Classical Mechanics: N.C. Rana and P.S. Joag, TMH, 1991.
4.	Classical Mechanics: Y. R. Waghmare, PHI, 1990.
5.	Classical Mechanics: V. B. Bhatia, Narosa Pub. House, 1997.
6.	Introduction to Classical Mechanics: R. G. Takwale and P. S. Puranik, Tata McGraw-Hill, 1990.
7.	Theory & Problems of Theoretical Mechanics: M. R. Spiegel, Schaum's Outline Series.

Course Name	**PH-413: General Electronics**
Course Code	PH-413
Course Type	Core
Course Outcome (CO)	(1) At the end of the course, the students will be able to understand the fundamentals of circuit analysis and working of analog as well as digital electronics. (2) Students will be able to use different theorems and techniques commonly used for circuit analysis. (3) Operational Amplifier being versatile circuit, students are exposed with different application of the operational amplifier. (4) By studying this course, students will be able to use different tools for combinational digital circuits designing. (5) Post completion of the course, student would be able to design sequential digital circuits.

Course Content	
Unit 1	**Network Analysis:** Review of Thevenin, Norton and Superposition theorems, Mesh and Node circuit analysis, T-Network analysis, π-Network analysis, conversions between T-Network section and π-Network section, Bridged-T network.
Unit 2	**Operational Amplifier Applications:** Summing, Scaling and Averaging amplifier, Instrumentation Amplifier, Voltage-to-Current converter with floating and grounded load, Current-to-Voltage converter, Integrator and Differentiator circuit, First-order Low pass, High pass, and Band pass filters. Phase shift oscillator, Square wave generator, Triangular wave generator, Saw tooth wave generator.
Unit 3	**Combinational Digital Circuit Design:** Standard Gate Assemblies, Arithmetic Functions, Digital Comparator, Parity Checker-Generator, Multiplexer, De-multiplexer, Encoder, Decoder, Digital to Analog Converter, Analog to Digital Converter.
Unit 4	**Sequential Digital Circuit Design:** Counters: Asynchronous Counter, Synchronous Counter, Ring counter, Application of counters. Shift Registers: Serial-in Serial-our shift register, Parallel-in Parallel-out shift register, Parallel-in Serial-out shift register, Serial-in Parallel-out shift register, Displays:7-Segment display, Alpha-Numeric display, Dot-matrix display and Multiplexed display system.

Reference Books	
1.	Electronic Fundamentals and Applications: J.D. Ryder, Prentice Hall of India, 1981.
2.	Electron Devices and Circuits: A Mottershed, Prentice Hall of India, 1981.
3.	Microelectronics: J. Millmann and A Grabel, Mc Graw Hill, 2009.
4.	Electronic Devices and Circuit theory: Robert L Boylestad & Louis Nashelsky, Pearson Education, 2007.

Course Name	**PH-414: Elective 1-Physics of Semiconductor Devices**
Course Code	PH-414
Course Type	Elective 1
Course Outcome (CO)	(1) After completion of the course, students shall acquire knowledge about core concepts and understanding the physical mechanism of charge carriers in semiconductor physics. (2) Students deals traditional as well as the contemporary power device and applications of these devices via thyristors family knowledge. (3) In junction diode covers p-n, metal-semiconductor and hetrojunctions detailed analysis developed to understand the operation of present–day device operation through the knowledge of the physics of semiconductor materials and devices. (4) In optical device students have acquired knowledge in photonic devices such that detection, generation and conversion of optical energy to electric energy or vice versa.

Course Content	
Unit 1	**Carrier transport phenomena and Thyristors:** Carrier transport phenomena: Mobility, Resistivity and Hall Effect, Recombination process, Phonon spectra, optical thermal and high field properties of semiconductor, basic equation for semiconductor device operation, Basic characteristic of three terminal Thyristor Reverse conducting Thyristors, Light activated Thyristor, DIAC and TRIAC, Uni-Junction Transistor and triggering Thyristor.
Unit 2	**Junction Diode:** Depletion region and depletion capacitance, Abrupt and linearly graded junctions, Current-Voltage characteristics, Ideal case- Shockley equation, Generation and recombination. Diffusion capacitance, Junction breakdown, Thermal instability, Tunneling effect, Avalanche multiplication, Terminal function. Metal-Semiconductor Contact, Energy band relation, Schottky effect, Ohmic contact, Heterojunction.
Unit 3	**Bipolar transistor:** Bipolar transistors, Static characteristic, Microwave transistors, Cutoff frequency, Microwave characterization, Device geometry and performance, Power transistors, switching transistor. Basic static performance parameters, non-ideal effect, Hetro-Bipolar Junction Transistor.
Unit 4	**Optical Devices:** Optical absorption: Photon absorption coefficient, Electron–Hall pair generation, Solar cell: PN Junction solar cell, Conversion efficiency and solar concentration, Heterojunction solar cell, Amorphous silicon solar cell, Photo-detectors, PIN photodiode, Light emitting diode, Laser diode.

Reference Books	
1.	Semiconductor Physics and devices: D.A. Neamen, Tata McGraw-Hill Publishing Company Limited, 2002.
2.	Physics of semiconductor devices: S.M. Sze, Wiley-Interscience, 1981.
3.	Solid State Electronic Devices: B.G. Streetman,(3^{rd} Ed.), Prentice-Hall of India Private Limited,1994.
4.	Semiconductor Devices: Jasprit Singh, McGraw-Hill Publishing Company Limited, 1994.

Course Name	**PH-414: Elective 2-Crystal Growth and Characterization**
Course Code	PH-414
Course Type	Elective 2
Course Outcome (CO)	(1) The development of crystal growth research group will become a focal point for not only academic based research but more broadly the research interests of the technological development. (2) How we think about the ways to crystallization impacts how we interpret natural crystallization processes in geochemical and biological environments as well as how we design and control synthetic crystal growth processes. (3) The study of different properties plays a major role in developing various applications of such materials grown by different techniques. (4) It is very useful for technological development.

Course Content	
Unit 1	**Crystal Growth Techniques:** Crystal growth, Crystal growth techniques, The chemical physics of crystal growth, Crystal growth from solution techniques, vapour growth techniques, How to start crystal growth, Advantages and disadvantages of crystal growth methods.
Unit 2	**Theory of Crystal Growth:** Nucleation, classical theory of nucleation, Gibbs Thomson equation for vapour, Modified Thompson's equation for melt, Gibbs Thomson equation for solution, Energy of formation of a nucleus, Spherical and cylindrical nucleus, Cap shaped and disc shaped nucleus.
Unit 3	**Characterization Tools:** Ultraviolet and visible absorption spectroscopy, Infrared spectroscopy, Basic components of infrared spectrophotometers, Fourier transform infrared spectroscopy (FTIR), Fluorescence spectroscopy, Principle and measurement Raman spectrometer, pH meters, Principle of pH measurement.
Unit 4	**Characterization Tools:** Optical microscopy and morphological studies of surfaces, Electron Spin resonance spectrometers, Scanning electron microscopy (SEM), Transmission electron microscopy (TEM) Atomic force microscopy (AFM) Thermo analytical methods, Thermo-gravimetric metric analysis (TGA), Differential thermal analysis (DTA), Simultaneous thermal analysis/Mass spectrometer.

Reference Books	
1.	Crystal Growth: P. Ramaswamy and Santhan Raghavan, Kru Publications–Chennai, 2000.
2.	Hand book of Analytical Instruments: R.S. Khandpur, Tata McGraw – Hill Professional Electrical Engineering Series (6^{th} Reprint), 2010.
3.	Crystal Growth Principles and Progress: A.W. Vere, Springer
4.	Nucleation and Crystal Growth: Metastability of Solution and Melts. Keshra Sangwal Wiley, 2010.
5.	Crystal Growth Concepts, Mechanisms and Applications: Jinjin Li, Jianwei Li and Yanhui Chy, 2017.
6.	Crystal Growth: Brain D. Pamplin (2^{nd} Ed.), 1980.
7.	Crystals and Crystal Growing: Alan Holder and Phylis Morrison, MIT Press, 1982.
8.	Introduction to Crystal Growth: Principles and Practice , H.L. Bhatt, CRC Press, 2014.
9.	Crystal Growth for Beginners Fundamentals of Nucleation, Crystal Growth and Epitaxy: Ivan V. Markov (2^{nd} Ed.), 2003.

Course Name	**PH-414: Elective 3- Numerical Methods**
Course Code	PH-414
Course Type	Elective 3
Course Outcome (CO)	(1) By studying this course students will be able to solve physical problems using numerical methods. (2) Students are able to perform curve and surface fitting using cubic splines. (3) Students are able to solve the simultaneous linear equation using different matrix methods. (4) Students are able to solve ordinary differential equation using different methods. (5) Students are able to solve partial differential equation using different methods.

Course Content	
Unit 1	**Spline Functions:** Linear Splines, Quadratic Splines, Cubic Splines, Minimizing Property of cubic splines, Error in the cubic splines and its derivatives, surface fitting by cubic Splines, Cubic B-splines Representation of B-splines, Least Squares, Solution Application of B-Splines.
Unit 2	**Numerical Linear Algebra:** Introduction, Triangular Matrices, LU Decomposition of A Matrix, Vector and Matrix Norms, Solution of Linear Systems—Direct Methods, Gauss Elimination, Necessity for Pivoting, Gauss-Jordan Method, Modification of the Gauss Method to Compute the Inverse, Number of Arithmetic Operations, LU Decomposition Method, Computational Procedure for LU Decomposition Method, LU Decomposition from Gauss Elimination, Solution of Tridiagonal Systems, III-conditioned Linear Systems, Method for III-conditioned Systems, Solution of Linear Systems—Iterative Methods, Matrix Eigen value Problem, A Eigen values of a Symmetric Tridiagonal Matrix, Householder's Method, QR Method, Singular Value Decomposition.
Unit 3	**Numerical Solution of Ordinary Differential Equation:** Introduction, Solution by Taylor's Series, Picard's Method of Successive Approximations, Euler's Method, Error Estimates for the Euler Method, Modified Euler's Method, Runge-Kutta Methods, Predictor-Corrector Methods, Adams-Moulton Method, Milne's Method, Cubic Spline Method, Simultaneous and Higher-order Equations, Some General Remarks, Boundary-value Problems, Finite-difference Method, Cubic Spline Method, Galerkin's Method.
Unit 4	**Numerical Solution of Partial Differential Equation:** Introduction, Laplace's Equation, Finite-difference Approximations to Derivatives, Solution of Laplace's Equation, Jacobi's Method, Gauss-Seidel Method, Successive Over-Relaxation (SOR) Method, ADI Method, Heat Equation in One Dimension, Finite-difference Approximations, Iterative Methods for the Solution of Equations, Application of Cubic Spline, Wave Equation, Software for Partial Differential Equations.

Reference Books	
1.	Introductory Methods of Numerical Analysis: S. S. Sastry, PHI, 2012.
2.	Numerical Methods for Scientists and Engineers: K. S. Rao, PHI, 2001.
3.	Numerical Mathematical Analysis: J. B. Scarborough, Oxford Books Co., 1962.
4.	Numerical methods for Engineers: S.C. Chapra, R.P. Canale, (5^{th} Ed)., McGraw Hill, 2006.
5.	Numerical Analysis for Scientists and Engineers: Theory and C Programs, Madhumangal Pal, Alpha Science International Ltd., 2007.

Course Name	**PH-414: Elective 4-Basic Nuclear Properties and Radioactivity**
Course Code	PH-414
Course Type	Elective 4
Course Outcome (CO)	(1) The students will learn basic nuclear properties and different methods of their measurements (2) The students will be introduced to the phenomenon radioactivity, types of radioactive radiations and their properties. They will also learn various applications of radioactivity. (3) The students will have in depth study of α-decay and β- decay processes and theories giving explanation of these decay processes. They will also learn forbidden decays and comparative half-lives. (4) The students will learn the process of γ- emission and basic conservation laws, internal conversion process, γ- ray spectroscopy and Mossbauer effect.

Course Content	
Unit 1	**Basic Nuclear Properties:** The nuclear radius, the distribution of nuclear charge, the distribution of nuclear matter, mass and abundance of nuclides, nuclide abundances, separated isotopes, laser isotope separation, nuclear binding energy, nuclear angular momentum, nuclear electromagnetic moments, nuclear excited states The deuteron, binding energy, spin and parity, magnetic dipole moment, electric quadrupole moment.
Unit 2	**Radioactive Decay:** The radioactive decay law, production and decay of radioactivity, growth of daughter activities, series of decays, types of decays, α-decay, β-decay, γ-decay, spontaneous fission, nuclear emission, branching ratios and partial half-lives, natural radioactivity, radioactive dating, units for measuring radiation, successive disintegrations.
Unit 3	**Alpha Decay and Beta Decay:** Alpha Decay: Why α-decay occurs, basic α-decay processes, α-decay systematics, theory of α-emission, angular momentum and parity in α-decay, α-decay spectroscopy, Beta Decay: Energy release in β-decay, Fermi theory of β-decay, the classical experimental tests of β-decay, the shape of the β-spectrum, the total decay rate, the mass of the neutrino, angular momentum and parity selection rules, allowed decays, forbidden decays, comparative half-lives and forbidden decays.
Unit 4	**Gamma Decay:** Energetics of gamma decay, classical electromagnetic radiation, angular momentum and parity selection rules, angular distribution and polarization measurements, internal conversion, lifetimes of γ-emission, gamma ray spectroscopy, nuclear resonance fluorescence and the Mossbauer effect.

Reference Books	
1.	Introductory Nuclear Physics: K. Krane, Wiley India Pvt. Ltd.
2.	Nuclear Physics by S. N. Ghoshal,S. Chand & Co. Pvt. Ltd., Revised enlarged edition, 2014.
3.	Nuclear Physics: D. C. Tayal, Himalaya Publishing House, 2017.
4.	Nuclear Physics: Roy & Nigam, Wiley Eastern Ltd., 1979
5.	Atomic and Nuclear Physics: S. N. Ghoshal, S. Chand & Company, 2019.
6.	Nuclear Models: W. Greiner and J.A. Maruhn, Springer, 1996.

Course Name	**PH-415: Practical**
Course Code	PH-415
Course Type	Core
Course Outcome (CO)	(1) After completion of the course, the students will be able to operate appropriate laboratory equipments and understand the principle allied with theories. (2) Students will be able to write computer programs as per the requirements. (3) Students are trained for trouble shootings while performing Design Build and Test type laboratory experiments.

Course Content	
	Group A
1.	Find out the power series solution of given differential equations.
2.	Find out the integral of given functions using contour integration.
3.	Find out the Fourier and Laplace transforms of given function.
4.	Find out the Spherical Harmonics for different values of *l*.
5.	Application of chi-square test.
	Group B
6.	To measure the period of oscillation of pendulum by changing angle and length using Variable ‘g’ pendulum setup.
7.	Transducer-I
8.	Transducer-II
9.	To determine the range of projectile as a function the angle of inclination using Projectile Motion experiment setup.
10.	To study the elastic and inelastic collision using Linear Air Track with digital timer setup.
	Group C
11.	Design build and test Voltage-to-Current converter using operation amplifier.
12.	Design build and test a Phase shift oscillator using operation amplifier.
13.	Design build and test Triangular wave generator using operation amplifier.
14.	Design build and test combinational logic circuit using multiplexer.
15.	Design, build and test 4- bit Up/Down counter using IC 7493
	Group D (Elective Paper 1)
16.	UJT relaxation oscillator.
17.	Power control using TRIAC and DIAC.
18.	Regulated power supply using Zener Diode.
19.	Solar cell characterization.
20.	Characteristics of Varactor Diode.
	Group D (Elective Paper 2)
16.	Crystal Grown by Slow Evaporation Method / Precipitation Method.
17.	Study of Piezoelectric effect.
18.	Study of chemical Etching for Grown Crystal.
19.	Structural study of crystalline material by using XRD.
20.	Study of Thermal Properties of material from TGA graph.
	Group D (Elective Paper 3)
16.	Determine the linear, quadratic and cubic spline for given data set.
17.	Solve the system of linear equations using matrix inversion with LU decomposition.

18.	Solve differential equation using the Picard's method.
19.	Solve differential equation using the Runge-Kutta method.
20.	Solve heat conduction problem using Crank-Nicolson formula.
Group D (Elective Paper 4)	
16.	Study of the characteristics of a GM tube and determination of its operating voltage, plateau length/slope etc.
17.	To find the dead time of GM tube using single source method.
18.	To determine the dead time of GM tube using double source method.
19.	To study energy resolution characteristics of a scintillation spectrometer as a function of applied high voltage and to determine the best operating voltage.
20.	To study Cs-137 spectrum and to calculate FWHM and determine resolution of a given scintillation detector.

Course Name	**PH-416:Skill based course-Measurement and Industrial Instrumentation**
Course Code	PH-416
Course Type	Skill based course
Course Outcome (CO)	(1) Post completion of the course, student boost their skill for utilization of equipments. (2) Student will acquire basic understanding and concept of measurement. (3) Student would know the usage of various measuring instruments.

Course Content	
Unit 1	**Measurement System and Analysis:** The Functional elements of an Instrument, Input Output configuration of measuring instruments and instrument systems. Dynamic characteristic: Generalized mathematical model of measurement system. Operational transfer function. Sinusoidal transfer function. Zero, first and second order instruments, frequency, ramp and step responses of first and second order instruments.
Unit 2	**Industrial Instrumentation:** Pressure measurement: Dynamics response consideration, Bourdon tube pressure gage. Diaphragm and Bellows gages. Transducer: The variable resistance transducer, The Linear Variable Differential Transformer (LVDT), Capacitive Transducer, Piezoelectric transducer, Photoelectric effect, Photoconductive transducer, Strain gauge transducer. Digital Displacement transducers, Flow measurement: Introduction, Flow obstructions methods, Hot wire and hot film anemometers. Magnetic flowmeters, Laser Doppler anemometer.

Reference Books	
1.	Measurement Systems: E. O. Dobelin, McGraw Hill.
2.	Experimental Methods for Engineers: J. P. Holman (7^{th} Ed) McGraw Hill.